THE FUNCTIONAL SIGNIFICANCE OF THE ARRANGEMENT OF THE CEREBRAL AND CEREBELLAR VEINS

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During a study of the Great Vein of Galen (1, 2), my attention was called to certain facts in connection with the veins draining blood from the cerebral hemispheres and the cerebellum. The points raised in this paper are the outcome of a fuller investigation of these facts and their interpretation.

It has long been known, and almost every anatomical text-book stresses the fact, that the superior cerebral veins open obliquely into the superior longitudinal sinus, and that their direction is opposed to that of the current of the blood in the sinus. Only a few books, however, attempt to give a reason for this arrangement, although at least three explanations have been offered at various times. In the first place, it has been suggested that this curious mode of termination in the sinus provides one of the factors which prevents sudden depletion of the cerebral veins in consequence of the inspiratory emptying of the large intracranial venous channels. Secondly, it has been pointed out that the arrangement prevents regurgitation of blood from the sinus into the cerebral veins: and thirdly, Symington (3) denied any functional significance and expressed the view that the obliquity of the superior cerebral veins appeared to be merely secondary to the backward growth of the cerebral hemispheres.

It is difficult to agree with Symington's suggestion that the arrangement has no functional importance when the investigation is extended to other veins draining the blood from the brain into the cerebral sinuses. A closer study of their structure and precise course, in the light of recent knowledge regarding the relative pressures of blood in the sinuses and the cerebro-spinal fluid, does seem to indicate that the arrangement serves a most important and useful physiological purpose.

CEREBRAL AND CEREBELLAR VEINS

At the outset, attention was directed to the superior cerebral veins, but as certain facts emerged the investigation was extended to the other veins conveying blood across the subarachnoid space from the various parts of the brain to the intracranial venous sinuses.

It was found that the number of superior cerebral veins opening into the superior longitudinal sinus was smaller than usually described, only four or five being observed on each side as a rule. These may be named, as Sargent (4) has proposed: Frontal, Precentral, Postcentral and Occipital. The smaller

Frontal commonly approaches the sinus at a right angle, but the others invariably extend forwards and inwards to open against the current. All these veins after crossing the subarachnoid space, run for a distance of about half-an-inch in the substance of the dura mater as usually stated: in this part of their course they may pass under a lacuna, but my observations confirm those of Le Gros Clark (5), in that the veins never discharge their contents into a lacuna but always open into the sinus direct. It is noteworthy that the meningeal veins, which of course do not cross the subarachnoid space, do not usually follow this oblique course and commonly open into the lacunae. The orifices of the superior cerebral veins in the sinus are so constructed and placed that they are maintained in a widely open condition when the sinus is filled with blood, in fact, they do not appear to collapse when the sinus is empty. The wide-open entrance to the veins has been demonstrated by several observers, who have found that fluid injected into the sinus from behind runs with the greatest readiness into the cortical veins, and by some, this observation has been used as an argument against the assumption that the obliquity has any functional significance.

Histological examination of sections of the veins, as they cross the subarachnoid space and as they extend to the sinus in the substance of the dura, reveals further points of interest. The thinness of the venous wall is well known, but the most remarkable feature in their structure is the reduction, when compared with veins from other regions, in the amount of muscle. Whilst traversing the subarachnoid space, the muscle coat forms only a very thin internal ring, which is surrounded by a fibrous layer forming about seven-eighths of the whole thickness of the wall. When the vessels pierce the dura, the muscular coat is still more insignificant, is even difficult to recognise without a differential stain, and does not always form a complete layer. In other words, the terminal part of the superior cerebral veins has a wall very similar to that of the sinus, and in this part of their course the veins may be considered as patent tubes, with fibrous walls outside the endothelial lining, which are extensions of the sinus.

Such an arrangement and structure do seem to infer a functional bearing, and this deduction is enhanced when reference is made to other veins entering the venous sinuses from the brain. My own observations make it evident that all the larger veins which cross the subarachnoid space have walls similar in structure to those just described, and enter the sinuses in the same manner. Their course in the substance of the dura may not always be of the same extent as that stated with regard to the superior cerebral veins, but the fundamental arrangement, in the case of those of sufficient size to make a satisfactory dissection, is the same.

THE PRESSURE OF THE CEREBRO-SPINAL FLUID AND THE BLOOD IN THE VENOUS SINUSES

From a large series of experiments the researches of Weed and Hughson (6) have demonstrated that in almost every case the pressure of the cerebro-spinal fluid was considerably higher than that of the pressure of the blood in the hinder part of the superior longitudinal sinus. The results of the work of Weed and Hughson confirmed the views of Dixon and Halliburton (7), who fifteen years ago had corrected the opinion expressed by Leonard Hill (8) that the cerebro-spinal fluid and cerebral venous pressures were the same. Consequently it seems to be established definitely that the cerebro-spinal fluid pressure is normally above that of the pressure in the intracranial sinuses. The venous sinuses possess strong walls and can withstand the pressure, but the veins which cross the subarachnoid space, where they are fully exposed to the cerebro-spinal fluid pressure, have thin walls. From the foregoing it is clear that these veins would collapse under the pressure exerted from without by the cerebro-spinal fluid if the pressure within them was no greater than that in the sinuses. This fact seems to have escaped recognition until it was appreciated by Brain (9), who pointed out that it is not legitimate to assume, as has been done, that the pressure in the cerebral veins is as low as that in the large intracranial sinuses. It is evident that the pressure in the veins crossing the subarachnoid space must be sufficiently high to withstand the pressure of the surrounding cerebro-spinal fluid, and I suggest that the arrangement described in this paper provides the mechanism by which the pressure in these veins is maintained above the level of that in the sinuses. The flow of blood in the sinuses passing the open orifices of the veins, which approach the sinuses against the current, will obviously impede the discharge of blood from the veins into the sinuses and so raise appreciably the pressure within the former. The fibrous nature of the wall of the veins, with a very meagre amount of muscle as they approach the sinus, is quite in accord with such a mechanical device. Such an arrangement will ensure that the pressure in the veins is probably sufficient, under normal circumstances, to enable them to withstand the cerebro-spinal fluid pressure. Conditions which prevail under abnormal circumstances are of clinical interest and reference must be made to them.

Whilst it is now well known that there is a relationship between arterial, venous and cerebro-spinal fluid pressures, there is also no doubt that the latter must be considered as more independent of the other two than was formerly believed. Evidence has been submitted to show (6, 10, 11) that the fluid pressure may be altered independently of any change in the intracranial and systemic vascular pressure. Consequently under abnormal circumstances, as an excessive production of cerebro-spinal fluid or serious interference with its absorption, the fluid pressure may be raised very considerably above the pressure in the sinuses. In such abnormal conditions the fluid pressure may be so raised as to compress or cause collapse of the veins crossing the subarachnoid space and so induce venous congestion of the nervous tissue. It appears probable that this is the cause of the venous engorgement of the cortex seen not uncommonly at post-mortem examination of cases which have suffered from a moderate degree of raised intracranial pressure. Elsewhere (1, 2) I have submitted evidence which strongly suggests that, in many patients suffering from raised intracranial pressure secondary to growths within the skull, the primary cause of the elevation of pressure is due to compression of the Great Vein of Galen. Such compression impedes the venous drainage from the choroid plexuses, raises the capillary pressure in these structures, and produces an increase in the production of cerebro-spinal fluid. The increased amount of cerebro-spinal fluid may escape from the ventricular system into the cisternae and general subarachnoid space, provided there is no obstruction at any point, and be insufficient to cause any very obvious dilatation of the ventricles. In this case the pressure in the subarachnoid space may be raised sufficiently to impede the drainage by the cerebral and cerebellar veins and so lead to a venous engorgement. If the increased production of cerebro-spinal fluid is greater in amount, the ventricles are liable to be dilated, the aqueduct being too narrow to provide an escape of the fluid at the same rate as its production, i.e. a relative obstruction—and in consequence the nervous tissue of the cerebral hemispheres is pressed against the resistant walls of the skull. This will interfere with the circulation of the cerebro-spinal fluid over the hemispheres, and will limit absorption, which in turn leads to an exaggeration of the already raised intracranial pressure. In such cases of greatly elevated intracranial pressure, the effect of the dilatation of the ventricles and compression of the nervous tissue against the membranes and bones is to produce the characteristic flattened and anaemic condition of the cortex seen so frequently post-mortem, after a pronounced rise of intracranial pressure. The flattening and pallor of the cortex is always associated with and recognised by the pathologist as an expression of internal hydrocephalus.

In this way the opposed post-mortem findings in cases exhibiting raised intracranial pressure of venous engorgement of the cortex or anaemia associated with varying degrees of flattening become intelligible.

SUMMARY

1. All the veins traversing the subarachnoid space pass obliquely to the intracranial sinuses, so that their course is opposed to the direction of the current of blood in the sinuses.

2. The orifices of these veins are so constructed and arranged that they are permanently open.

3. Sections of the veins as they cross the subarachnoid space and pierce the dura show their walls to be very thin and almost entirely composed of fibrous tissue.

4. It is suggested that this arrangement and structure have a functional

significance, and served to raise the pressure in the veins and prevent their collapse by the pressure of the cerebro-spinal fluid surrounding them.

5. Reference is made to the influence of elevated intracranial pressure upon these veins.

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